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(54) THERMALLY OPERATED SWITCH

(71) We, TEXAS INSTRUMENTS INCORPORATED, a Corporation organized according to the laws of the State of Delaware, United States of America, of 13500 North Central Expressway, Dallas, Texas, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to thermally operated switches, and is of particular, but not exclusive application to the protection of the winding of an electric motor.

If an electrically driven appliance jams the windings of the motor take a much larger current than is present when the motor is running normally, and it has been proposed to provide a thermally operated switch responsive to the rise in temperature of the windings due to the greater current through the windings to open the circuit feeding current to the motor, so as to avoid damage to the windings by overheating. Once the circuit has been opened, and the current path interrupted, the windings cool down, but, if the appliance remains switched on, when the windings are cool enough the circuit is automatically closed again so that excessive current again flows through the winding of the jammed motor, once more causing it to heat up and operate the thermal switch. This is, of course, undesirable in that it subjects the winding to unnecessary heating cycles, and it has been proposed to provide a holding relay to keep the circuit opened until the appliance is switched off and then on again. This arrangement, though satisfactory, is bulky and expensive.

It is an object of the present invention to avoid the above difficulties.

According to the present invention, there is provided a thermally operated switch including a pair of normally closed contact members which separate when the switch is heated to a predetermined temperature, and a resistor having a positive temperature coefficient of resistance which is connected from one to the other of the contact members, the resistor being in heat transmission relationship with a temperature expensive element coupled so as to cause the contact members to separate, wherein one of the contact members has a non developable surface portion so as to provide a snap action between the closed and open positions of the switch.

The resistor continues to pass current to the winding after the contact members of the switch have been open circuited but the current is very much smaller, for example of a few milliamps, and too small for the winding to be damaged. The heat developed by the current flow through the resistor is sufficient to keep the contact members of the switch apart so that re-starting of the motor is only possible after the current has been switched off for a sufficient time for the switch to cool. The motor will also have cooled.

The PTC resistor may be a block located mechanically directly between and at the base of the two contact members, so that the heat developed by the resistor is readily conducted to the members. At least one of the contact members may include a bimetallic strip including the non-developable surface part to impart the desired snap action to the switch.

The resistance-temperature characteristic of the PTC resistor may show a steep rise in resistance with temperature up to a transition or Curie point at which the rate of increase of resistance with temperature increases. The current through the resistor will tend to stabilise itself near the Curie point so that the temperature of the resistor will not rise excessively.

One contact member may have a part made of electrical resistance material so that it acts as an eleetric heating element, so that when the current through the winding rises the greater heat from this element is transmitted to the bimetallic strip and produces a more rapid operation of the switch than would be achieved with the bimetallic strip responsive to the heating of the winding alone. In this way, the damage to the winding due to over-heating can be reduced still

In order that the invention may be fully understood and readily carried into effect, it will now be described with reference to the examples of the invention illustrated in the accompanying drawings of which:—

Figure 1 is a front view of a switch according to one example of the invention, partly in section;

Figure 2 is a side view of the switch of Figure 1, again partly in section;

Figure 3 shows an end view of the switch of Figure 1.

Figure 4 is similar to Figure 2, but the contact members are shown in the open circuit position and connections are provided to the terminals;

Figure 5 is a front view of a second example of the invention shown partly in section; and

Figure 6 is a side view again partly in section of the switch of Figure 5.

Referring now to Figures 1 to 4, the example of the invention shown consists of a case 1 in which is placed a block 2 of insulation material. Supported on the block 2 is a first terminal 3 and a second terminal 4. The terminal 3 is in contact with a bimetallic strip 6 forming a first contact member. The terminal 4 has formed integrally with it a second and fixed contact member, and between the two contact members there is placed a block 5 of resistance material having a positive temperature coefficient of resistance. The bimetallic strip 6 has an indentation 7 so that that part of the strip is in the form of a non-developable surface. The components of the switch are sealed within the case 1 by means of a suitable sealant 10 such as a cement or putty which protects the switch against penetration of moisture into the case.

The second contact member 4 as shown in Figures 2 and 4 is supported by the case 1 which is shaped so as to hold this member in a predetermined position. The moving end of the bimetallic strip 6 is provided with a switch contact button 9 which normally rests in contact with the contact member 4 so as to provide a closed-circuit connection between the two contact members. By virtue of the indentation in the bi-metallic strip 6 the switch contact button 9 is caused to move quickly away from the second contact member 4 with a snap action when the switch reaches a predetermined temperature. The bimetallic strip 6 causes the switch to be sensitive to increase in temperature and the indentation provides the snap action. Figure 4 shows the bimetallic strip 6 in the open-circuited position into which it springs when the predetermined temperature is reached.

When the switch is connected in series with, for example, the winding of an electric motor, and an excessive current is caused to flow from the winding so that it becomes over-heated, the bimetallic strip 6 which is in the position shown in Figure 2 springs to the open-circuited position shown in Figure 4 on reaching the predetermined temperature, which is selected, so as to avoid as far as possible damage to the winding of the motor due to over-heating, taking into consideration delays due to thermal inertia. When the switch moves to the open-circuit position the block 5 of resistance material is no longer short-circuited by the contact members being joined together and a current will flow through the block and through the winding of the motor. The block 5 when cold has a relatively low resistance, but its resistance rises steeply with increase in temperature, and at the predetermined temperature at which the switch opens its resistance is sufficient to reduce the current through the winding to avoid further over-heating of the winding. The passage of current through the block 5, however, causes it to rise in temperature further until it reaches a resistance such that the current is so reduced that the heat input to it due to current flow through the resistance is equal to the heat radiated and conducted from it. The temperature at which this occurs is prevented from being sufficiently high to damage the switch or any other components adjacent to it by providing the resistance material with a transition or Curie point at which the resistivity of the material rises even more steeply with the temperature. As a result of this the resistance block 5 tends to stabilise at a temperature close to the Curie point.

Because of the heat generated by the current flow through the resistance block 5, the bimetallic strip 6 is maintained in the position shown in Figure 4, even though the winding being protected may have cooled down. The block 5 being in mechanical contact with the bimetallic strip 6 has a good thermal and electrical connection to it.

Referring now to Figures 5 and 6, in which parts corresponding to the parts of the example shown in Figures 1 and 4 carry the same references as in those Figures, the second example of the invention shown differs from the first in that the second contact member 4 of Figures 1 to 4 has been replaced by a modified second contact mem-

ber 4′ as shown in Figures 5 and 6 in which the arm is provided with a narrowed part 11 which is made of electrical resistance material. In addition, the block 2 of insulation material has been replaced by a block 2′ adjacent to the second contact member 4′ instead of being adjacent to the terminal 3 as in the first example. In other respects the construction of the second example of the invention is similar to that of the first.

The second example of the invention operates in a manner similar to that described above with reference to Figures 1 to 4 after the switch has opened, but beforehand the operation of the switch is affected by a modification to the second contact member which is provided to accelerate the opening of the switch after the excessive current has started to flow. It has been found in some circumstances that the delays in the open-circuiting of the switch of Figures 1 to 4 are sufficient for the winding for example being protected to become damaged by over-heating because of thermal inertia within the switch, and the arrangement shown in Figures 5 and 6 overcomes this difficulty by passing the current through the switch along the narrowed part 11 of the second contact member 4′. The narrowed part 11 acts as a heater, and when the excessive current is flowing it produces a greater quantity of heat, which, by virtue of its proximity to the bimetallic strip 6, causes the switch to open quickly in response to the increased current.

By placing the insulating block 2′ adjacent to the second contact member 4′, heating losses from this contact member are reduced and it is therefore more effective to heat up the bimetallic strip 6.

Although the invention has been described with reference to a thermally operated switch for protecting the winding of an electric motor, it can, of course, be used to protect a variety of electrical appliances from damage due to excessive current flow. It is desirable that the switch should be placed as close as possible to the winding or other electrical part to be protected so that it can respond as quickly as possible to undesirable increases in temperature.

The switches described above can be modified in a number of ways, for example, by interposing a spring between the resistance block 5 and the second contact member so that the block 5 is firmly clamped against the bimetallic strip 6. It is, of course, not essential that the resistance block 5 be placed between the first and second contact members providing it is in good thermal contact with the bimetallic strip 6, and in another embodiment of a switch according to the invention, the block 5 is placed against the bimetallic strip 6 on the side remote from the second contact member, and a connection is provided joining the second contact member to the face of the block 5 remote from the bimetallic strip 6, possibly with the interposition of a spring to clamp the block 5 against the strip 6.

WHAT WE CLAIM IS:—

1. A thermally operated switch including a pair of normally closed contact members which separate when the switch is heated to a predetermined temperature, and a resistor having a positive temperature coefficient of resistance which is connected from one to the other of the contact members, the resistor being in heat transmission relationship with a temperature responsive element coupled so as to cause the contact members to separate wherein one of the contact members includes a non-developable surface portion so as to provide a snap action between the closed and open positions of the switch.

2. A switch according to Claim 1, in which the one of the contact members includes a bimetallic strip with the non-developable surface portion forming the temperature responsive element.

3. A switch according to claim 2 in which the resistor is a block of resistance material mounted adjacent to at least the one of the contact members.

4. A switch according to Claim 3 in which the block is placed between the contact members and is mechanically and electrically clamped to both contact members.

5. A switch according to Claim 3 in which the block is pressed against the one contact member by means of a spring.

6. A switch according to any preceding claim in which one contact member includes a part which operates as an electric heating element to cause the contact members when closed to become heated in response to electric current passed by the switch.

7. A switch according to Claim 2, in which the other of the contact members includes a narrowed part of electrical resistance material, positioned so that heat from the narrowed part is conveyed to the bimetallic strip.

8. A switch according to Claim 7 in which heat insulating material is provided to reduce heat transfer from the narrowed part other than to the bimetallic strip.

9. A switch according to any of Claims 1 to 6 in which one contact member is fixed.

10. A switch according to Claim 9 in which the resistor is a block of resistance material mounted against the other contact member on the side remote from the fixed contact member.

11. A switch according to Claim 9 in

which a casing is provided enclosing the contact members and the fixed contact member abuts against the inside of the casing.

12. A thermally operated switch substantially as herein described with reference to Figures 1 to 4 or Figures 5 and 6 of the accompanying drawings.

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1,342,274 COMPLETE SPECIFICATION
2 SHEETS
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SHEET 1

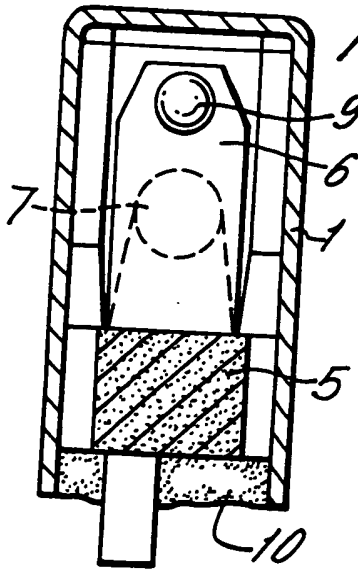


Fig. 1

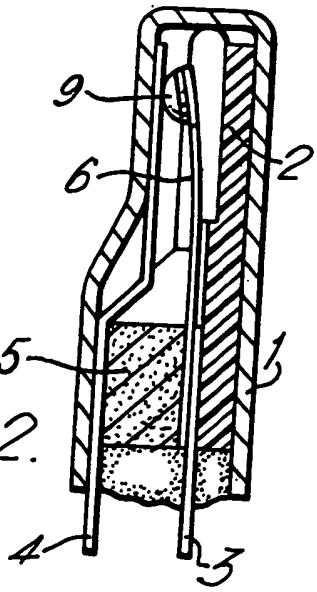


Fig. 2.

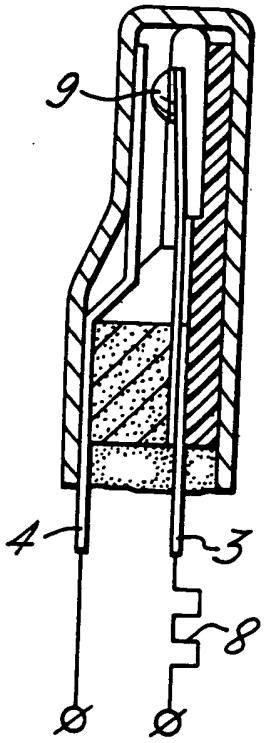
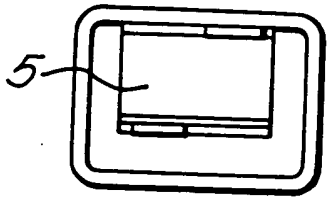


Fig. 4.

Fig. 3.



1,342,274 COMPLETE SPECIFICATION
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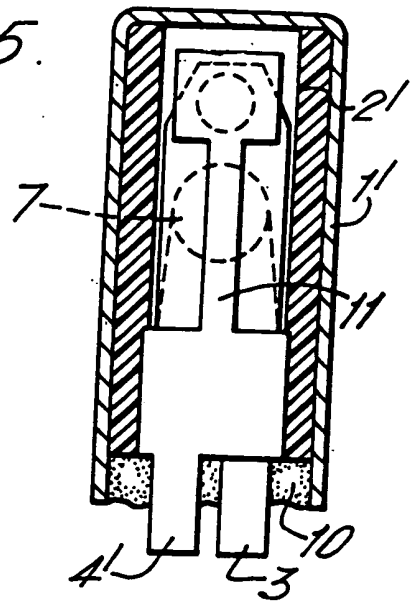
SHEET 2

Fig. 5.



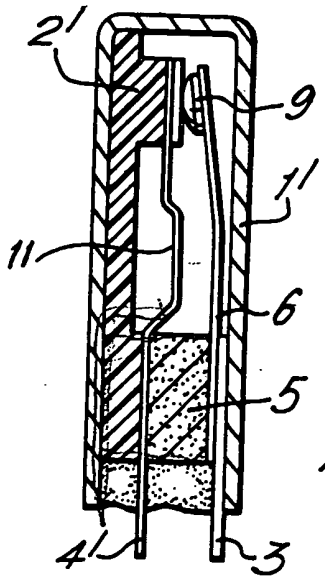


Fig. 6.